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THE EFFECTIVENESS OF TAPE PLAYBACK IN ESTIMATING BLACK RAIL DENSITY

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Abstract: We measured the vocal responses and movements of radiotagged black rails

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(*Laterallus jamaicensis; 26 M, 17 F*) to playback of vocalizations at 2 sites in Florida during the breeding seasons of 1992--95. We used regression coefficients from logistic regression equations to model probability of a response conditional to the birds' sex, nesting status, distance to playback source, and time of survey. With a probability of 0.811, non nesting male black rails were most likely to respond to playback, while nesting females were the least likely to respond (probability = 0.189). We used linear regression to determine daily, monthly, and annual variation in response from weekly playback surveys along a fixed route during the breeding seasons of 1993-95. Significant sources of variation in the linear regression model were month ($F_3 = 3.89$, $P = 0.014$), year ($F_2 = 9.37$, $P < 0.001$), temperature ($F_1 = 5.44$, $P = 0.024$), and month*year ($F_5 = 2.69$, $P = 0.031$). The model was highly significant ($P < 0.001$) and explained 53% of the variation of mean response per survey period ($R^2 = 0.5353$). We combined response probability data from radiotagged black rails with playback survey route data to provide a density estimate of 0.25 birds/ha for the St. Johns National Wildlife Refuge. The relation between the number of black rails heard during playback surveys to the actual number present was influenced by a number of variables. We recommend caution when making density estimates from tape playback surveys.

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Key words: black rail, conditional probability, density estimation, Florida, *Laterallus jamaicensis*, radiotelemetry, surveying techniques, tape playback, vocalizations, wetlands.

Black rails are small cryptic birds that inhabit dense marshes, which makes them difficult to observe and hinders population studies (Todd 1977, Davidson 1992). Using tape playback to elicit vocalizations is an efficient way of determining the presence of elusive birds (Glahn 1974, Marion et al. 1981, Gibbs and Melvin 1993). Biologists have used playback to determine black rail presence or absence, or relative density (Weske 1969, Repking and Omhart 1977, Griese et al. 1980, Kerlinger and Sutton 1989, Runde et al. 1990, Evens et al. 1991). Despite the frequent use of this technique, the percentage of black rails that respond to playback is unknown. The availability of small (<2 g) radiotransmitters and portable tracking equipment allowed us to determine the effect of playback recordings on the vocal behavior and movements of black rails.

Our objective was to refine survey methodology for black rails and to determine the effectiveness of playback surveys to provide an estimate of density. To meet these objectives we needed to (1) quantify the response rate of black rails to playback, and to determine the factors which influence response rate; (2) document black rail movements before they vocalize in response to playback; and (3) identify optimal daily timing, seasonal timing, and weather conditions for playback surveys.

STUDY AREAS

We studied black rails at 2 sites in Florida. From May--August 1992 and March--August 1993, we worked at the end of State Road 361, 18 km south of Jena, Dixie County, (Jena). This site was on private land owned by the Packaging Corporation of America and was next to the Jena Unit of the Big Bend Wildlife Management Area which was managed by the Florida Game and Fresh Water Fish Commission. Dominant vegetation was needlerush (*Juncus roemerianus*), spikegrass (*Distichlis spicata*), and silverling (*Baccharis angustifolia*). Approximately 50 ha of suitable black rail habitat occur between the marsh--upland interface.

From March--August 1993, April--August 1994, and May--August 1995, we worked at the 2,000-ha St. Johns National Wildlife Refuge (St. Johns), 5 km west of Titusville, Brevard County, Florida. St. Johns is a relict saltmarsh basin bordering the St. Johns River (Baker 1973), where dominant plant species include cordgrass (*Spartina bakeri*), wax myrtle (*Myrica cerifera*), and sawgrass (*Cladium jamaicensis*). Logistics of trapping limited the study area to a strip 300 m east and west of a 2.2 km dike road that bisects the St. Johns from north to south; hence our effective study area was 132 ha. St. Johns is approximately 200 km east--southeast of Jena.

METHODS

Trapping

We captured black rails with double-door box traps and drift fences made from nylon netting as described by Flores and Eddleman (1993). We placed traplines in areas where (1) black rails were heard calling, (2) a black rail was flushed, or (3) an area that had mud and dense vegetation and was used by black rails (M. L. Legare, personal observation). We banded, radiotagged, and released birds at the capture site. The sex of each bird was determined via ventral plumage color (Eddleman et al. 1994). After a black rail capture, we removed all traps and drift fences from the area to minimize disturbance and to prevent the same black rail from being recaptured. If we captured no black rails within 3 days, we moved the traps. Generally, no trapping locations were used >1 time / year. However, we reused successful trap sites from previous years in subsequent years. The University of Rhode Island Animal Care and Use Committee approved this research.

Radiotelemetry

Because black rails are so difficult to observe, we used radiotelemetry to determine the presence of an individual black rail for testing response to playback and to document movement in response to playback. In 1992, we radiotagged black rails with 1.6-g radiotransmitters (Wildlife Materials, Carbondale, Illinois, USA). In subsequent years, we used 1.4-g transmitters (Holohill Systems, Carp, Ontario, Canada). Transmitters never exceeded 4% of the bird's body mass. In 1992, we attached transmitters on the bird's back between the wings, using eyelash cement and cyanoacrylic glue, a cotton string backpack harness, or both. In subsequent years, we used livestock ear-tag cement applied directly to the transmitter and the bird's skin (D. G. Krementz, University of Georgia, personal communication). We released all birds within 10 min after transmitters were attached.

We determined birds' movements and responses to playback via null--peak mobile and fixed telemetry stations (Legare 1996). We determined bearing errors for both fixed and mobile telemetry stations by placing test transmitters at the base of wooden stakes. We surveyed all stakes, fixed towers, and mobile receiving locations to <2 m using a Trimble Pathfinder Professional GPS receiver (Trimble Navigation, Sunnyvale, California, USA). True bearings from test transmitters to receiving equipment were determined by entering the known

Universal Transverse Mercator (UTM) coordinates for both the receiving stations and transmitter locations (Snyder 1982) into a computer program (White and Garrott 1990:86). The bearing error was the standard deviation of the difference between actual and observed bearings recorded from test transmitters (White and Garrott 1990). Telemetry station bearing errors were $\pm 1.2°$ for fixed station 1 and $\pm 1.5°$ for fixed station 2. The mobile null--peak antennas each had bearing error of $\pm 2.5°$. All telemetry information was recorded and saved using Locate II radiotracking software (Pacer, Truro, Nova Scotia, Canada).

Vocal Response

We measured response to playback by locating radiotagged birds and then monitoring their response to tape playback.. To conduct a vocal response trial, we located the radiotagged bird via a 3-element hand-held Yagi antenna and then exposed it to 1 min of *Kic-kic-kerr* and *Growl*, or *Kic-kic-kerr* and *Churt* vocalizations (Eddleman et al. 1994). We recorded vocalizations at the study sites and broadcast tapes over powerhorn speakers with the sound approximating 90 dB directly in front of the speaker (Flores and Eddleman 1990). Sonographs for vocal displays used in this study appear in previous published studies (Reynard 1974, Eddleman et al. 1994). We assumed that any black rail vocalizations heard from the position indicated by the hand-held antenna were coming from monitored birds. To minimize vocal habituation and to maximize independence between trials, we repeated each trial at ≥36-hr intervals during the early morning (0630--0830) and early evening (1900--2030). All playback experiments occurred between March and August of each year. We conducted no trials when wind velocity was ≥20 km/hr, or during rain, and we varied observer position as the habitat would permit. One objective was to determine black rail movements in response to playback tape, so we never positioned an observer where obstacles (i.e. ponds, roads, bare ground, etc.) would influence black rail movement. We used telemetry to determine the nesting status for each bird. Nesting birds were inactive for a portion of the day; hence, we located their nests by following the telemetry signal to the incubating bird. Data recorded from these trials included time, date, bird identification number, sex, call played, call heard, time to response, nesting status, and distance from tape source to radiotagged bird.

Movement

To determine black rail movements in response to playback, assistants located radiotagged birds from either the mobile or fixed telemetry receiving stations. After we determined the bird's location on the study site, we used a combination of 2 mobile stations, 1 mobile and 1 fixed station, or 2 fixed stations to monitor the bird's movement. At all times, 1 telemetry station was at the same location as the playback source. We obtained 2 simultaneous azimuths and recorded the location via the radiotracking software. A third person then played 1 min of taped black rail vocalizations a known distance (≤100 m) from the monitored bird. The observer playing the survey tape remained in contact with assistants monitoring the telemetry equipment via 2-way radio when the monitored bird was heard responding. At this time, the assistants relocated the bird being monitored and recorded this second location. Communication via 2-way radio and precise timing determined movements in response to the tape before the monitored bird vocalized. Data recorded from these trials included bird identification number, sex, call played, call heard, observer to bird distance, distance moved before detection, time to response, time, and date. We conducted movement and playback trials at the same time, except when 2 observers were not available. When extra assistance was unavailable, we obtained only information on response rate.

Daily and Seasonal Timing, Weather Variables

We conducted morning and evening playback surveys independently of telemetry experiments to determine the optimal timing of surveys. We conducted 2 surveys within 12 hr of each other every 1--2 weeks and paired these surveys to compare results from morning versus evening surveys. We completed morning surveys within 3 hr of sunrise, and we conducted evening surveys from 2 hr before sunset to 1 hr after sunset.

We located permanent survey stations within both study areas. Stations consisted of stakes 1.5 m tall, placed in a linear transect 100 m apart. The observer recorded the time, date, air temperature, wind velocity, and percent cloud cover after locating the survey station. We divided the total survey time at each station into 3 2-min periods. The observer listened for 2 min, played the taped vocalizations for 2 min, and then listened for another 2 min. Playback tapes were 1-min endless-loop tapes with approximately 30 sec of recorded tape and 30 sec of blank tape. We varied playback tapes for these surveys by using recordings made from different individual black rails and by alternating the vocalizations. All playback tapes had the *Kic-kic-kerr* vocalizations plus either the *Growl* or *Churt*. When we heard a black rail vocalize, we recorded the vocalization type (*Kic-kic-kerr*, *Growl*, *Churt*), direction, and distance from the station. We recorded as repeats those black rails suspected of calling from a previous station or time period. We assumed birds were "repeats" when the observer determined the vocalizing bird was in the same location as a previously vocalizing bird, when an individual bird called without stopping during survey time periods, or when an individual black rail could be heard from several stations. We included no birds determined to be "repeats" when calculating the mean number of birds per station.

Data Analysis

We analyzed data from only the first 5 playback trials on each individual bird to reduce the effects of pseudoreplication. We coded only birds that responded within 3 min of the playback trial as having responded. We used this time limit for comparison with the weekly surveys conducted on the St. Johns and Jena sites.

Because of the binary nature of black rail response (response, no response), we used logistic regression (SAS PROC CATMOD; SAS Institute, Inc. 1994) to model the independent variable black rail response (RESPONSE; 0 = no response, 1 = response) in relation to the dependent variables of tape (TAPE; 0 = *Kic-kic-kerr* and *Growl*, 1 = *Kic-kic-kerr* and *Churt*), observer to bird distance (DISTANCE; m), sex (SEX; 0 = M, 1= F), time of day (PERIOD; 0 = morning, 1 = evening), site (SITE; 0 = Jena, 1 = St. Johns), nesting status (NEST; 0 = non nesting, 1= nesting), and count (COUNT; no. of trials on that individual black rail, 1--5). We used PROC CATMOD because of the categorical data collected, and the ability of CATMOD to incorporate interactions between variables. We used the variable called "count" to determine the effect of repeated observations on individual birds. Because PROC CATMOD does not have a stepwise selection feature, we used backward selection on the full regression model to determine the best model for predicting response (Zar 1995). We retained variables significant at the $P \leq 0.05$ level. We calculated odds ratios and 95% confidence intervals for those ratios (Hosmer and Lemeshow 1989) to determine the effect of each significant variable on black rail response.

To determine if males and females responded with different vocalizations, we used a 2 * 3 chi-square contingency table with sex and 3 vocalization types (*Kic-kic-kerr*, *Growl*, and *Churt*) to compare the vocalizations used by males and females in response to playback. We calculated descriptive statistics to describe the length of time that male and female black rails required to give a vocal response to playback. We recorded movement by a black rail in response to playback as positive (toward the playback source), none (no movement measured), or negative (away from the playback source). The distance moved in relation to the playback source represents the distance from the original location determined by telemetry to the location at which the bird vocalized in response to the playback.

We used linear regression to determine which weather and timing variables had a significant effect on mean number of birds heard per station (Norman and Streiner 1994). The variables included in the model were month, year, time period, temperature, cloud cover, and wind velocity. We performed backward selection on the full regression model and retained only variables contributing significantly ($P \leq 0.05$) to the model.

We used information obtained during telemetry playback trials to refine an estimate of black rail density (i.e. the number of birds per unit area). We calculated the area surveyed in this study via the fixed-radius circular plot technique. The number of birds within this plot was calculated as (no. observed) * (1/the detection probability), which generated the general density estimate

$$d = \frac{n\,(1/p)}{a}$$

where n is the number of black rails heard, p is the probability of detection, and a is the area surveyed.

RESULTS

Vocal Response

We captured 56 individual black rails during 4,380 trapnights; 43 were radiotagged and exposed to playback experiments. We conducted playback trials on 26 males and 17 females between 1992--95, including 9 birds at the Jena site and 34 birds at the St. Johns; 134 trials met our criterion of ≤5 trials/individual. We located 19 active nests during this study and determined the nesting status for each bird via telemetry monitoring (M. L. Legare, unpublished data).

During the first 3 min after playback, 50% (n = 91) of male black rails gave a vocal response. After an additional 8 min, another 14% of males responded. Among females (n = 43), 20% gave a vocal response during the first 3 min, and nearly half of those responses were within the first min, before the playback ended. Within a further 8 min, another 20% gave a vocal response. Male and female black rails responded to playback trials with different vocalizations. Males responded with the *Kic-kic-kerr* vocalization during 48% of the trials (n = 91), with the *Growl* 46%, and with *Churt* 6%. Females responded with *Kic-kic-kerr* in only 5% of the trials (n = 43), *Growl* in 29%, and *Churt* in 65%. This difference between vocal displays used by males and females was highly significant ($\chi^2_2 = 36.50$, $P < 0.001$).

The final model statement derived was

model response = period + site + nest + distance * nest sex * count + distance * sex

Backward selection eliminated all but 4 of these factors (period, nest status, and the distance * nest and distance * sex interactions). Responses were higher in the morning (odds ratio = 3.48, 95% CI = 1.49--8.13, $P = 0.005$), and higher for non nesting birds (odds ratio = 10.85, 95% CI = 1.97--59.8, $P = 0.009$). We obtained significant interactions between nesting and distance, and between distance and sex, indicating responses increased with decreasing distance from the observer to nesting black rails (odds ratio = 1.02/m distance, 95% CI = 1.00--1.04, $P = 0.023$), and that responses were greater for males than females at increasing distances (odds ratio = 1.01/m distance, 95% CI = 1.00--1.06, $P = 0.023$).

Movement

Birds did not respond when beyond 80 m. Male responses were greatest at 60 m, while female responses peaked at 20 m (Fig. 1). Males moved toward the playback source during 57% of the playback trials, remained in the same location during 37% of the trials, and moved away from the tape source during 6% of the trials. Males moved a mean distance of 9.5 m (SD = 12.8, minimum = 2, maximum = 60, $n = 91$) toward the playback source. Females moved toward the playback source during 44% of the trials, remained in the same location during 53%, and moved away during 3% of the trials. Females moved a mean distance of 4.9 m (SD = 8.4, minimum = 2, maximum = 35, $n = 42$) toward the playback source. Using a combination of fixed and mobile antennas allowed positioning 1 antenna at the tape source. Usually when the monitored bird moved, it moved in line with the antenna at the tape source, and we recorded its movement by a change in bearing from the second monitoring location.

Daily and Seasonal Timing, Weather Variables

We repeated techniques for playback surveys along fixed routes to determine optimal daily, seasonal, and weather conditions for future playback surveys (Glahn 1974, Conway et al. 1993, Gibbs and Melvin 1993). During weekly surveys, black rails did not vocalize often at Jena; too few vocalizations were recorded in 1992 or 1993 to conduct analysis of this data. Black rails were heard vocalizing during both years, but few birds responded to playbacks.

We conducted 30 paired morning and evening call--response surveys from 1993--95 at St. Johns. The mean number of black rails heard per survey station was greatest during the end of July, while the fewest responses were heard in June (Table 1). Significant sources of variation in the linear regression model were month ($F = 3.89$, df = 3, $P = 0.0140$), year ($F = 9.37$, df = 2, $P = 0.0003$), temperature ($F = 5.44$, df = 1, $P = 0.0236$), and month*year ($F = 2.69$, df = 5, $P = 0.0311$). The model was highly significant ($P < 0.0001$) and explained 53% of the variation of mean response per survey period ($R^2 = 0.5353$). Mean response per station was not affected by wind velocity, cloud cover, or daily timing (morning or evening) ($P > 0.05$).

Density Estimate

We learned that the probability of a response from a black rail varies with distance from the playback source, sex, breeding stage, and time of the survey. We used logistic regression equations (Table 2) to model the probability of a response conditional to the bird's sex, nesting status, distance to playback source, and time of the survey. The logistic regression equation relating the probability of response, $p_{ijk}(r)$, at a distance, r from the tape given the i level of sex, the j level of nesting status, and the k level of time period is

$$p_{ijk}(r) = \exp[\alpha j + \beta k + (\delta i + \phi j)\, r]/\{1+\exp[\alpha j + \beta k + (\delta i + \phi j)r]\},$$

where αj, βk, and δi and ϕj are the regression coefficients for the variables nesting status, time period, and the interaction between distance and sex and the distance and nest. For example, the probability that a non nesting male black rail responds in the morning, as a function of distance, is

$$p_{ijk}(r) = \exp\,[0.6240+1.1923+(-0.217+0.015)r]/\{1+\exp[0.6240+1.1923+(-0.217+0.015)r]\}.$$

Second, the probability of response averaged over distance, but conditional on the bird's sex, nesting status, and time of survey, $pijk$, was calculated as in Buckland (1987):

$$p_{ijk} = \text{effective area / survey area} = 2\pi\, r\, p_{ijk}(\mathrm{r})\, dr\, /\, (\pi\, w^2),$$

where w is the distance at which observations are truncated; for this study $w = 80$ m. These conditional probabilities are listed for all combinations of sex, nesting status, and time of survey (Table 3). The probability of response was then averaged over the variables sex and nesting status by assuming an even sex ratio (Eddleman et al. 1994) and 70% nesting birds (M. L. Legare, unpublished data). The law of total probability then implies that the unconditional or averaged probability of a response from a black rail at time period I is

$$p_i = \Sigma\, p_{ijk}\, p(jk),$$

where the $p(jk)$ is the probability of a bird with characteristics j and k. For example, the probability of a response from a black rail in the morning, p_{AM}, is

$$p_{AM} = 0.811(0.5)(0.7) + 0.78(0.5)(0.3) + 0.465(0.5)(0.7) + 0.45(0.5)(0.3) = 0.6311.$$

Similarly, the probability of a response from a black rail in the evening was calculated as 0.369.

We estimated density at 0.25 birds/ha, using the average number of black rails heard per morning survey from 1993 to 1995 on the 21 station St. Johns survey route (6.72) and the previously calculated probability of a response in the morning:

$$d = n_{AM} (1/ p_{AM}) / a = 6.72(1/0.6311) / 42 \text{ ha} = 0.25 \text{ birds / ha}.$$

DISCUSSION

Vocal Response

From March through August, males responded to playback nearly twice as often as did females. Several authors have posited a territorial defense or advertising function of the *Kic-kic-kerr* vocalization given by the male (Weske 1969, Reynard 1974, Kerlinger and Wiedner 1990). For the purposes of this study, we did not consider the ethological functions of vocalizations, but rather reproduced playback techniques that have been reported in previous studies of rallids (Tacha 1975, Repking and Ohmart 1977, Johnson 1984, Evens et al. 1991, Flores 1991, Crowley 1994) and applied them to radiotagged black rails.

We found 4 published studies that tested playback response from other rallids. Nesting soras (*Porzana carolina*) responded to playback during 20--100% of trials, while nesting Virginia rails (*Rallus limicola*) responded during 22--72% of trials. Variation in both species depended on breeding stage (Glahn 1974). The response rate to playbacks by common moorhens (*Gallinula chloropus*) located via nest searches and visual observations was 93% for males and 21% for females (Brackney and Bookhout 1982). Spotless crakes (*Porzana tabuensis*) observed from blinds during nesting were exposed to taped calls, and 38% responded within the first 2 min of playback (Kaufmann 1988), with the crake response rate decreasing between minutes 1--6, but then increasing at minute 7. Radiotagged Yuma clapper rails (*Rallus longirostris yumanensis*) showed significant differences in response with season: 40% of birds responded during the early breeding season, but only 20% responded during the late breeding season (Conway et al. 1993).

Movement

Black rails moved in response to playback recordings. Previous studies have attempted to quantify the movements of calling black rails based on estimating the locations of calling birds (Weske 1969, Evens et al. 1986) but were unable to determine black rail locations before vocalizing. Black rail movement before auditory detection is a source of bias for any estimate of density based on the distance to calling birds. In 1 Maryland study, black rails moved toward playback during 14 of 24 trials, remained in the same location during 9 of 24 trials, and moved away from the tape source during only 1 of 24 trials (Weske 1969). Spotless crakes observed at nests while exposed to playback responded vigorously to recorded calls during the early stages of breeding, but they did not respond after incubation began. Some vocalized while moving toward the tape source, whereas others did not vocalize until approaching (Kaufmann 1988).

Daily and Seasonal Timing, Weather Variables

We found that during weekly playback surveys along a fixed route, temperature, month of survey (breeding stage), and year of survey affected response rate. Responses during these weekly surveys of unmarked birds were not influenced by survey period (morning or evening), cloud cover, or wind velocity. These findings conflict with the data from our observations of radiotagged birds. Opportunistic observations of freely calling birds indicated black rails were most vocal within 30 min of civil sunset (M. L. Legare, personal observation). Such individuals might have influenced the data obtained during the surveys along fixed routes. Vocal behavior of birds changes with time of day (Shields 1977), so surveys should be conducted with knowledge of this variance. Tacha (1975) observed that response by breeding king (*Rallus elegans*), sora, and Virginia rails did not vary with temperature and cloud cover, but that increased wind velocity reduced the numbers of birds heard. In our study, surveys were not conducted when the wind velocity was >20 km/hr, which may account for our not having detected any effect of wind velocity.

During weekly surveys along the fixed route, black rail responses were higher during the prenesting (Apr) and postnesting (Jul) periods of 1993 and 1994, and lower during the nesting periods (May, Jun) of both years. Most studies of rail vocalizations have reported peak calling activity during the prenesting period, with continual decline to postnesting (Johnson 1984, Kaufmann 1988, Kerlinger and Wiedner 1990, Conway et al. 1993). Black rails at St. Johns showed a second peak in vocal activity during post-nesting. Several authors have reported similar findings (Glahn 1974, Flores 1991). This second peak may involve juveniles, adults dispersing from brood territories, or both. During 1993, 1994, and 1995, birds were heard calling in late July and August at survey stations where no birds had responded during April--early July. Regular calling by black rails only during the prenesting period has been reported from the Northeast, where black rails are likely migratory (Weske 1969, Kerlinger and Wiedner 1990). Migratory birds may cease calling after nesting. Reports that black rails only vocalize during the prenesting stage might be an artifact of reduced number of observations during the late breeding season, and lack of year-round studies where birds are permanent or quasi-permanent residents.

Density Estimates

Because black rails are inconspicuous and secretive, 2 parameters necessary to estimate density sample area *a*, and number *n*, of individuals are difficult to measure. Previous studies of inconspicuous bird species have used circular plots to determine sample area (Marion et al. 1981, Evens et al. 1986). One important assumption when using this technique is that birds are detected at the original location, and do not move relative to the observer (Buckland et al. 1993). Black rails clearly do not meet this assumption. Evens et al. (1986) recognized this violation and attempted to measure movement before detection by measuring the movements of birds based on vocalizations, and assuming that the birds moved the same distance before calling; they presented density estimates for black rails using a version of a fixed radius plot. They counted 84 black rails at 45 stations, each considered the center of a 36.2 m radius plot, for an effective survey area of 18.52 ha, and an estimated density of 4.53 rails/ha. We used radio telemetry to determine the tape source-to-bird distance *before* the tape was played. Black rails *did* move toward the playback before vocalizing, which should preclude the use of the circular plot technique where the radius of the plot circle is determined solely by the distance at which the black rail vocalizes. Such use of circular plots results in overestimates of density. For example, playback in this study effectively surveyed black rails to a distance of 80 m (Fig. 1). Incorporating this value into the Evens et al. (1986) data changes their area surveyed to 90.45 ha, and gives a density estimate of 0.93 birds/ha. Clearly, determining the effective survey area of circular plot surveys is critical to determining population density.

Playback surveys do not detect all black rails within the area sampled. No published information exists regarding the relationship between the number of black rails detected vs the actual number present. Detection probability has been measured on other bird species using radio-telemetry, observations of nesting birds, and estimates based on repetitions of survey transects (Conway et al. 1993, Buckland 1987, Kaufmann 1988). These studies have indicated that a significant proportion of birds can remain undetected during surveys.

Several factors influenced the probability that a black rail within the plot would respond to the playback and be detected, including time of day, nesting status, distance and nesting interaction, and a distance and bird sex interaction. During the telemetry playback trials, the odds of a black rail responding to playback were 3.48 times higher in the evening than in the morning, yet the weekly surveys found no difference in mean response during morning and evening surveys. Freely calling birds may have influenced the data for weekly surveys. When comparing data from the telemetry portion of this study and the weekly survey portion of this study, the advantage of knowing the location of the bird places more confidence on the telemetry data.

Nesting status affects black rail response. The odds of response were 10.85 times higher for non-nesting black rails than for nesting birds. Previous studies have indicated that vocal behavior peaks during pre-nesting and declines after incubation has begun (Kauffman 1988). A significant interaction occurred between nesting and distance to tape source. Nesting black rails were less likely to respond with increasing tape source-to-bird distance. The odds of a nesting black rail responding were 1.02 times higher for every meter the distance the tape-source-to bird distance decreased. Distance is normally assumed to have an inverse relationship with detection probability (Buckland et al. 1993), that is, the greater the observer-to-bird distance the less likely that bird will be detected. The interaction of distance and sex indicate that this is true for female black rails, but males increase their response with increasing distance up to an inflection point (Fig. 1).

Males were more likely to be detected than females. Variation in detection with bird sex has been reported in many species (Bibby 1992, Buckland et al. 1993) and this is likely because of the function of vocalizations played during surveys. If males are responsible for territorial defense, then they are more likely to respond to playback vocalizations that represent intruders. If playback includes a solicitation vocalization, then unmated birds would be more likely to respond. Vocalizations have meaning and playback vocalization type may influence detection.

Both males and females were included in the density estimates provided. Using the telemetry information, we were able to refine the estimate of the probability for detecting black rails (assuming an even sex ratio and 70% were nesting during the survey period). The sex ratio assumption is based on our own capture data and previous published reports (summarized in Eddleman et al. 1994). The percentage of black rails that were breeding was derived solely from data collected during this study (M. Legare unpubl. data).

MANAGEMENT IMPLICATIONS

Density estimates for black rails may be obtained from playback surveys, and fixed radius circular plots. Circular plots should be considered as having a radius of 80 m and be located so the plot centers are 150 m apart. Playback tapes should contain one series of *Kic-kic-kerr* and *Growl* vocalizations recorded within the same geographic region as the study area. Vocalizations should be recorded on endless loop tapes and be free of distortion. Surveys should be conducted from 0-2 hours after sunrise or 0-2 hours before sunset, during the pre-nesting season, and when wind velocity is <20 kph. Observers should listen for 3-4 minutes after playing the survey tape and record responses heard during that time. Observers should be trained to identify black rail vocalizations and should have acceptable hearing ability.

Given the number of variables which may have large effects on the response behavior of black rails to tape playback, we recommend that future studies using playback surveys should not present estimates of absolute density. Though our density estimate did account for variation in response behavior, we believe that additional variation in vocal response between sites, with breeding status, and bird density remains in question. Playback surveys along fixed routes providing a simple index of abundance would be useful to monitor populations over large geographic areas, and over time. Future telemetry studies of this type would be useful to calibrate information obtained from playback surveys whether reporting an index of abundance or density estimate.

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Table 1. Mean daily, monthly, and annual black rail response during weekly playback surveys on the St. Johns National Wildlife Refuge, Brevard Co., Florida, 1993-95.

Variable	n[a]	Response Rate[b]	S.D.
Time of day			
Morning	52	.32	.17
Evening	49	.38	.23
Month			
April	17	.33	.13
May	13	.30	.13
June	17	.23	.14
July	15	.51	.29
August	3	.23	.09
Year			
1993	35	.31	.23
1994	17	.46	.17
1995	13	.24	.08

[a] No. of surveys

[b] Birds per station

Table 2. Factors affecting vocal response to playback, data from radiotagged black rails at the St. Johns National Wildlife Refuge and Jena Unit sites, 1992-95. Regression coefficients from the logistic regression [1] (model response = period + nesting status + distance * sex + distance * nesting status).

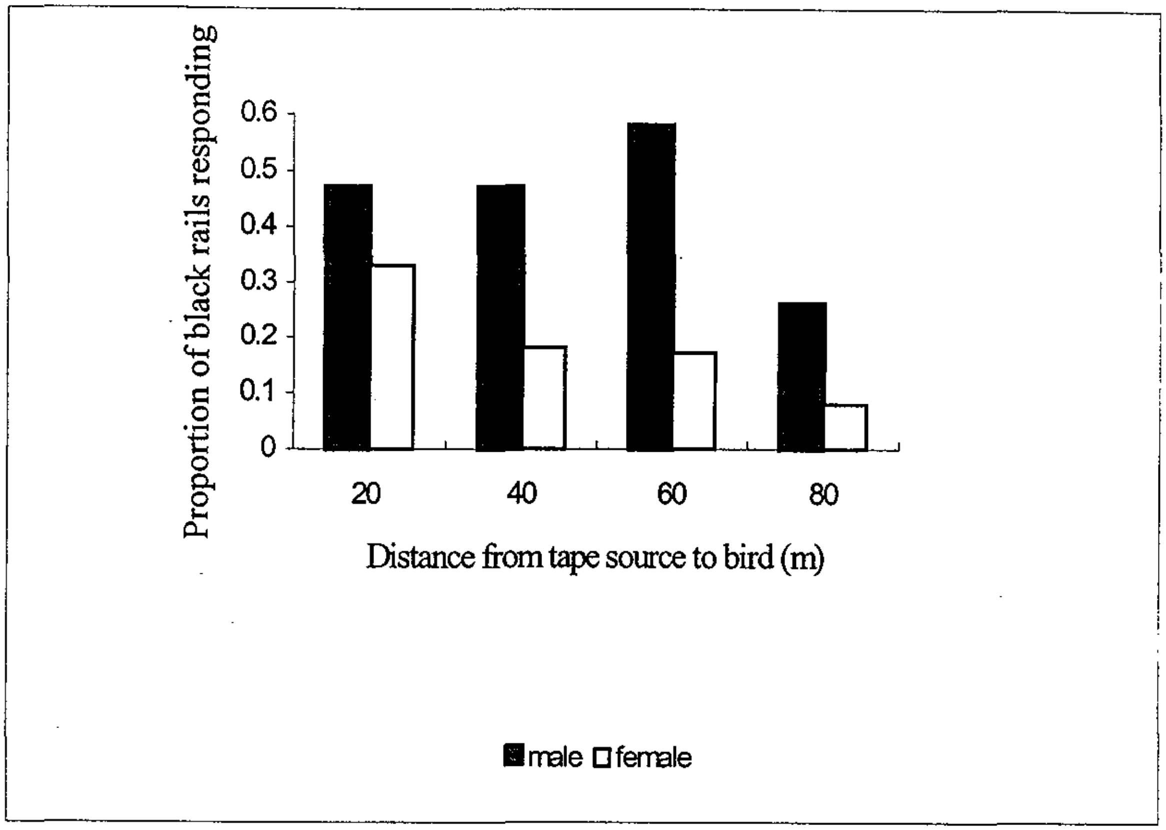
Effect	Parameter	Estimate	Standard error	χ^2	P
Period	1	-0.6240	0.2160	8.34	0.0039
Nest	2	-1.1923	0.4356	7.49	0.0062
Distance*Nest	3	0.0217	0.00956	5.17	0.0230
Sex*Count	4	-0.4349	0.6071	0.51	0.4738
	5	-0.5705	0.4642	1.51	0.2190
	6	0.4282	0.4337	0.97	0.3235
	7	1.1683	0.4574	6.52	0.0106
Distance*Sex	8	-0.0150	0.00537	7.75	0.0054

[1] Using the SAS CATMOD procedure (SAS Institute, Inc. 1994).

Table 3. Unconditional probability of response over all distances within 80 m circular plots, by black rails of different nesting status and sex, for different survey periods at the St. Johns National Wildlife Refuge, 1993-95, Brevard Co., Florida.

Bird status and survey time	Probability of response
Male, non-nesting, morning survey	0.811
Male, non-nesting, evening survey	0.552
Male, nesting, morning survey	0.780
Male, nesting, evening survey	0.535
Female, non-nesting, morning survey	0.465
Female, non-nesting, evening survey	0.220
Female, nesting, morning survey	0.450
Female, nesting, evening survey	0.189

Figure 1. Proportion of radiotagged black rails responding to playback at 20-m intervals from tape source. Only birds responding within 3 minutes of tape playing are included. Jena, Dixie Co., FL, and St. Johns National Wildlife Refuge, Brevard Co., FL, 1993-95.


Proportion of black rails responding
0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80
Distance from tape source to bird (m)
male
female